S29, Tuesday Morning

Conversion efficiency of 6.X nm Emitted from Nd:YAG and CO_2 Laser Produced Plasma

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Summary

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- **Conversion efficiency, angular distribution, spatial profile of 6.X nm emission were measured by using Co/C multilayer mirrors.**

- **1.5 - 1.7% of the conversion efficiency has been attained with 1 x 10^{12} - 1 x 10^{13} W/cm^2 of Nd:YAG laser intensity and Gadolinium targets.**

- **Conversion efficiency depends weakly on durations of Nd:YAG laser pulse.**

- **Minimum thickness of Gadolinium layer is 400 nm for sufficient 6.X nm emission.**

- **Punch-out scheme will be studied to supply minimum mass Gadolinium targets.**

6.X nm is selected, because La/B_4C and Mo/B_4C multilayer mirror has high reflectivity for the light.

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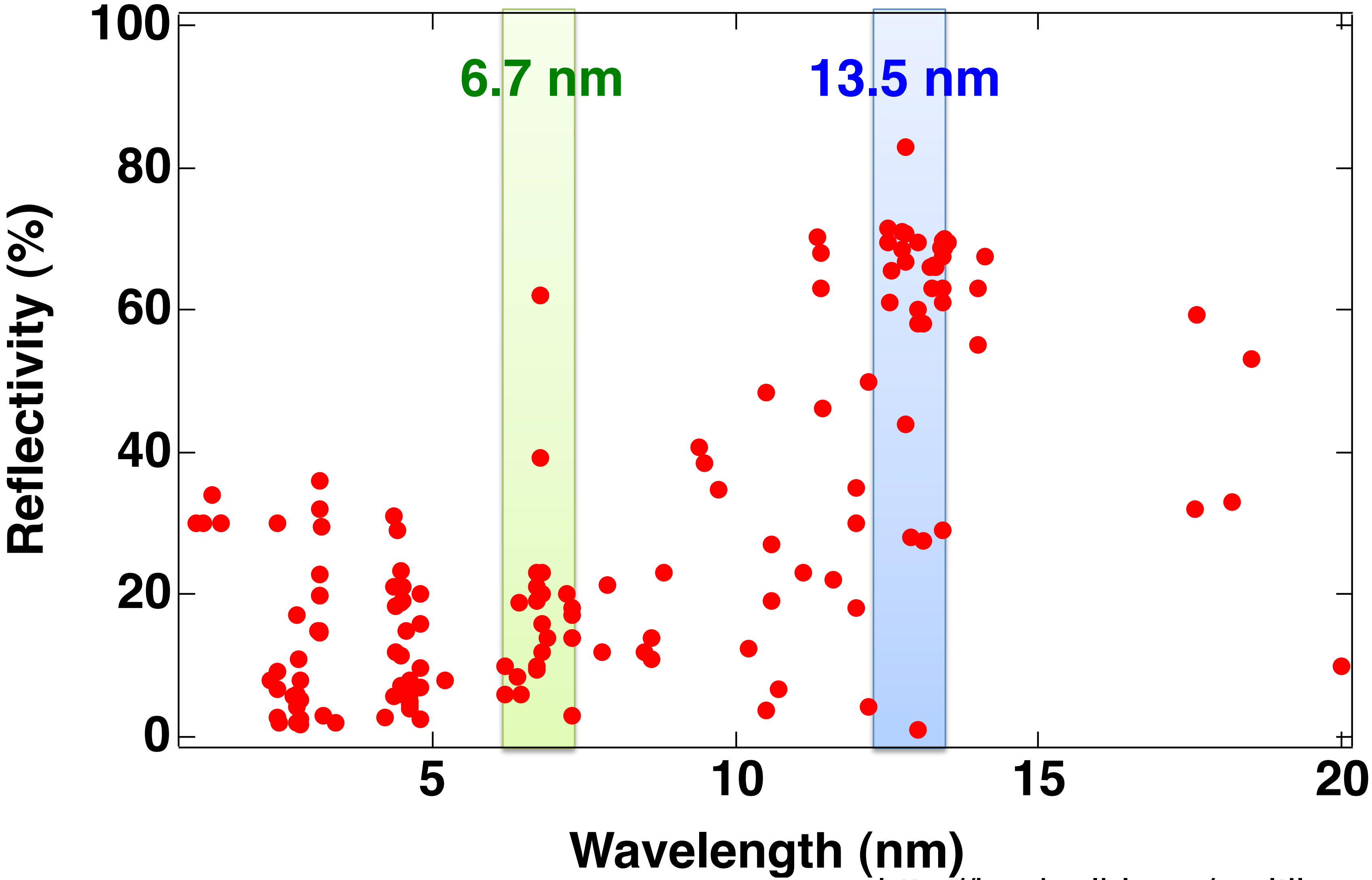
Reported reflectivity of MLMs in EUV range



http://henke.lbl.gov/multilayer/survey

The 6.X calorimeter consists of two Co/C mirrors and a photodiode.

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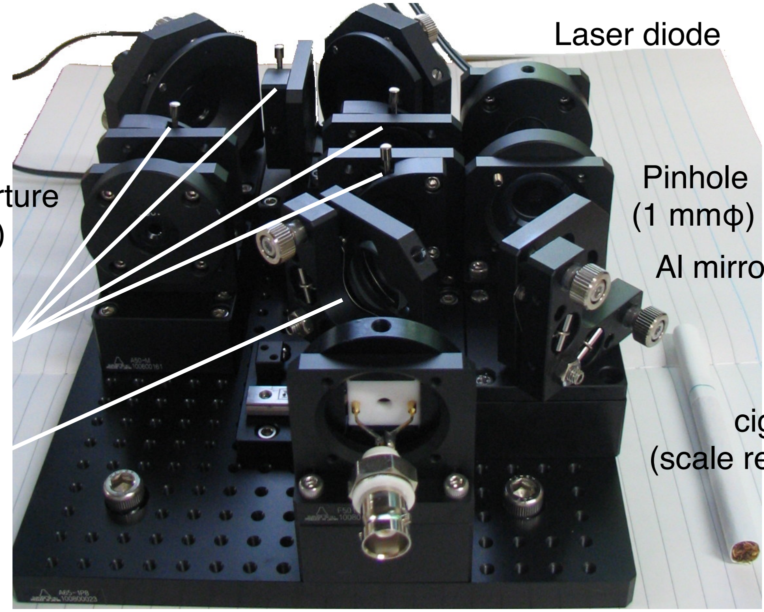

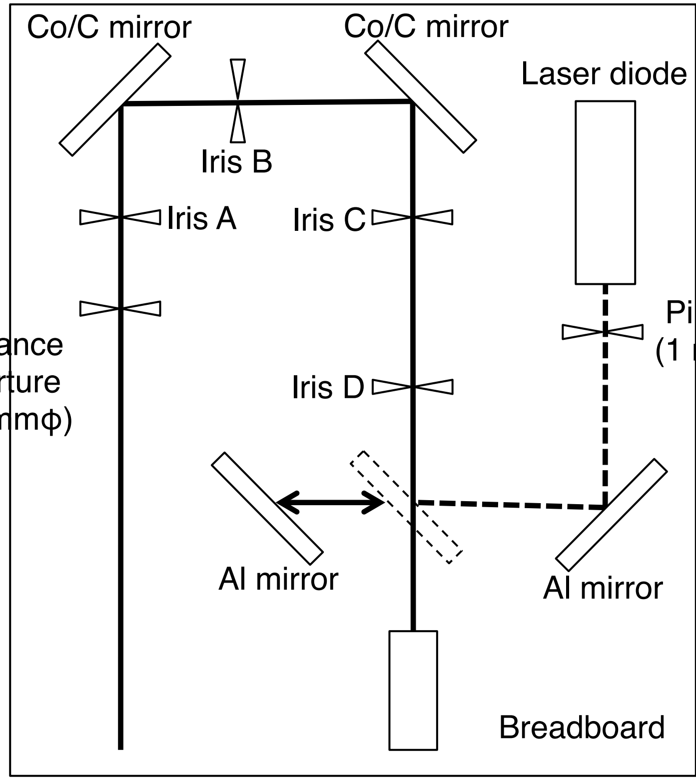

We have prepared the following diagnostics:

- **Mini-calorimeter to measure angular distribution of emission.**
- **Monochromatic 6.X nm imager to identify emission dominant region.**
- **2400 lines/mm reflective grating spectrometer .**
- **2000 lines/mm transmission grating spectrometer.**

The Co/C mirrors has a wide bandwidth.
Flexible for change of the targeted wavelength.

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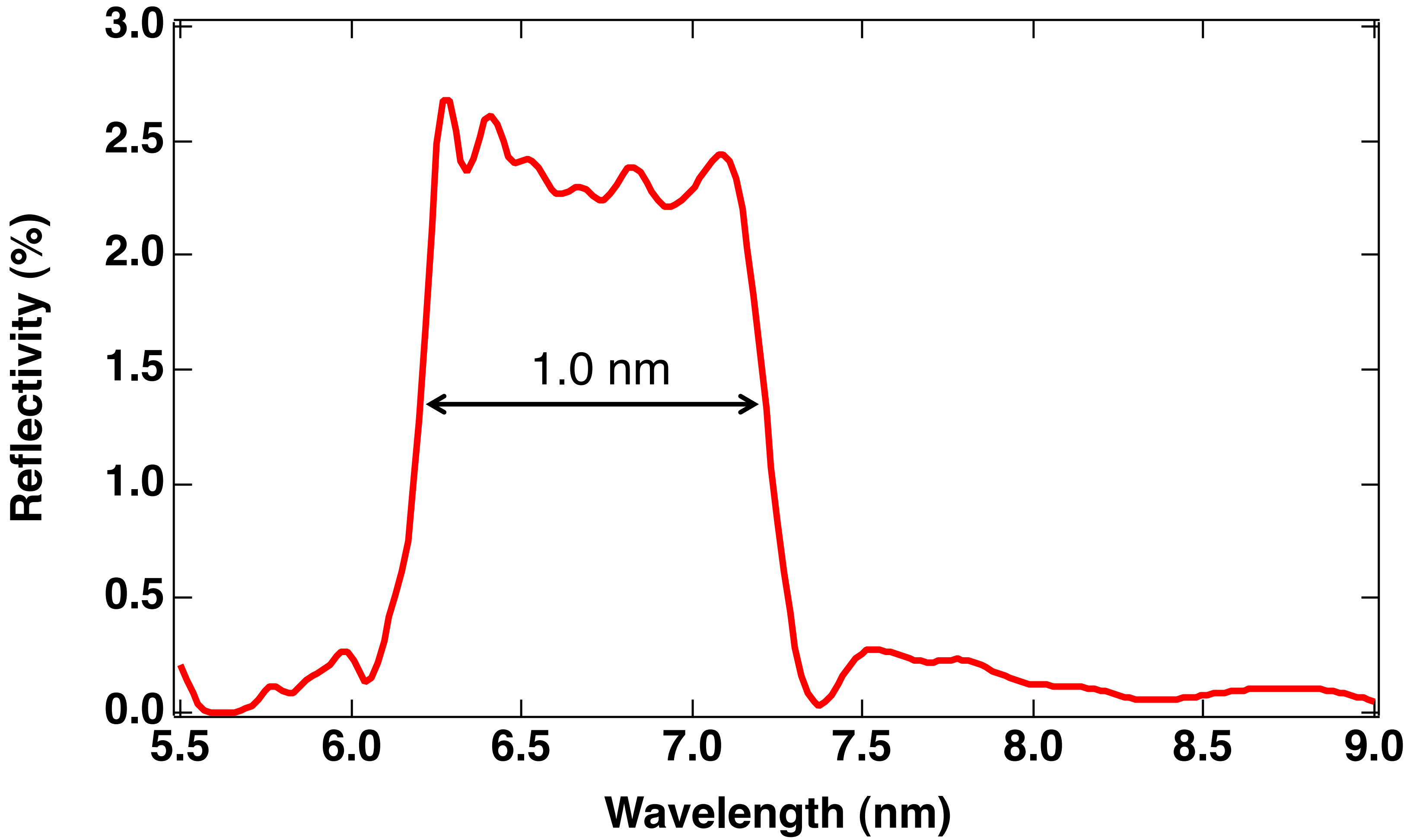
Measured reflectivity of Co/C in EUV range



Fabricated by Rigaku Innovative Technology

Energy, spectrum, in-band image, and angular distribution were measured.

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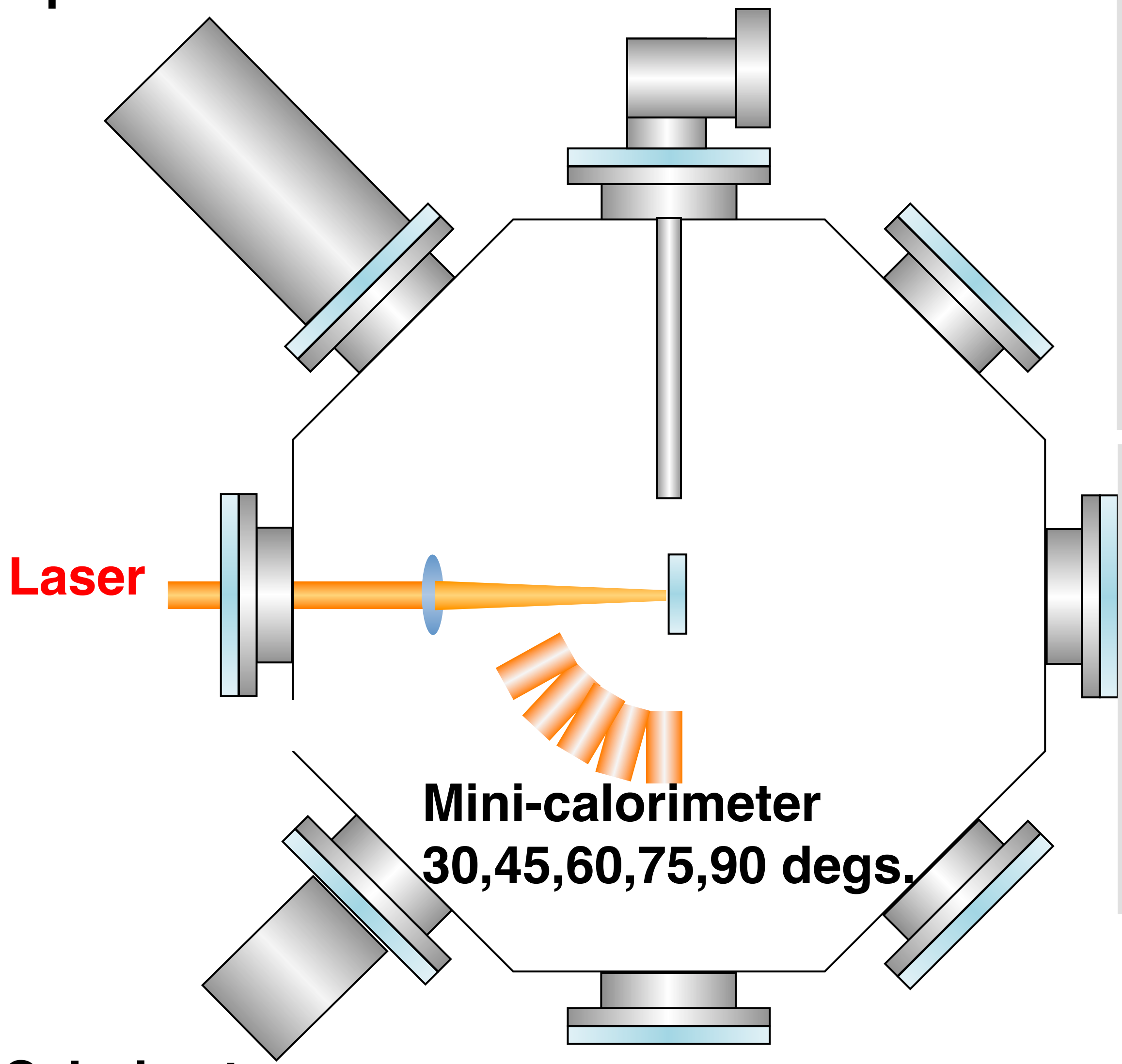

Nd:YAG laser

Wavelength:	1.064 μm
Pulse duration:	2 ~ 10 ns (tunable)
Energy:	0.1 ~ 50 J (tunable)
Spot size	100 or 250 μm (tunable)

CO_2 laser

Wavelength:	10.6 μm
Pulse duration:	30 ~ 40 ns (fixed)
Energy:	0.1 J (fixed)
Spot size	100 μm (fixed)

6.X images show the emission region becomes lager by longer duration of irradiated laser pulse.

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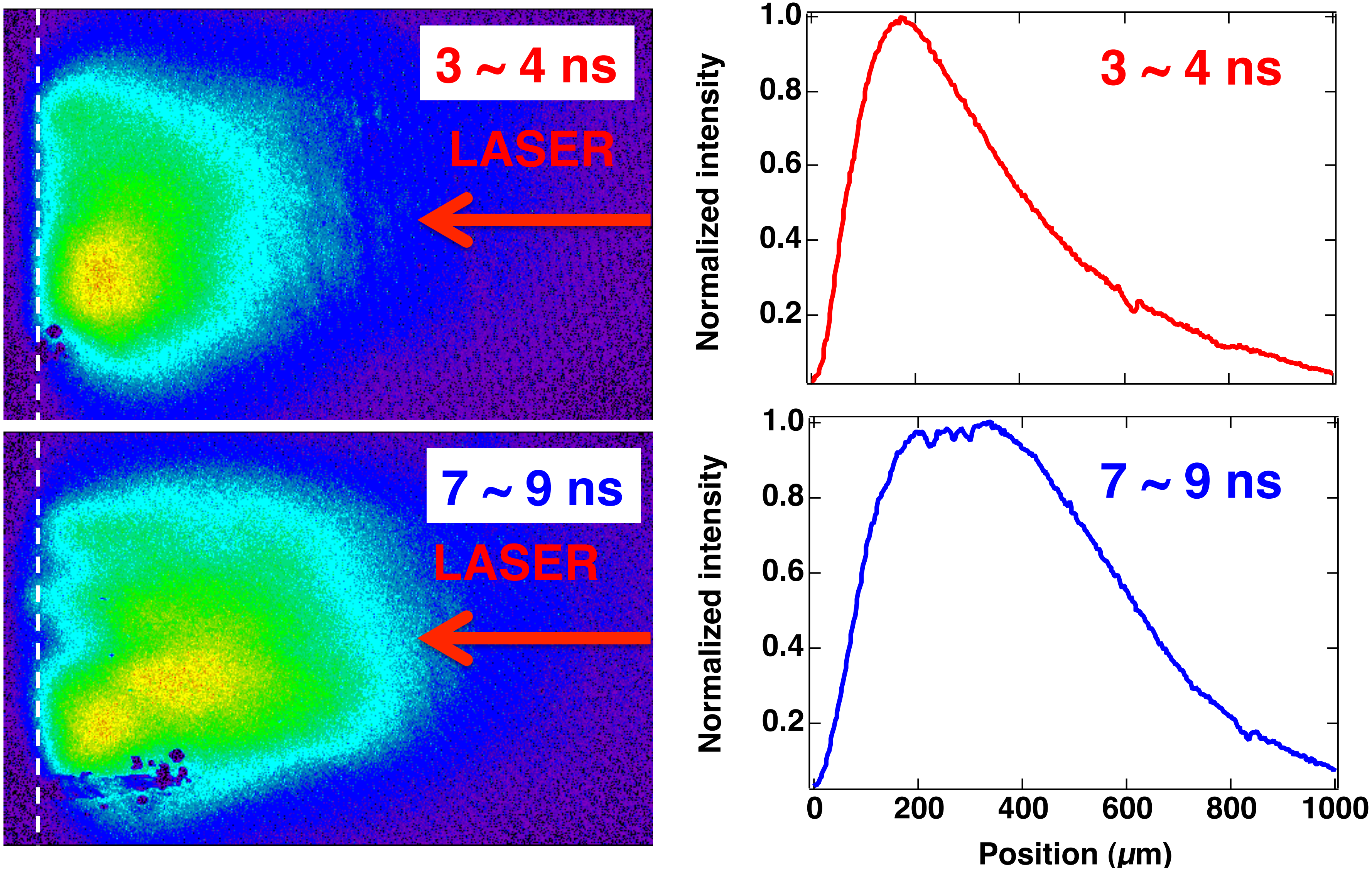
In-band images of Gd plasmas



Angular distribution for 7-9 ns is more anisotropic ($\gamma = 0.63$) compared to that for 3-4 ns ($\gamma = 0.55$) .

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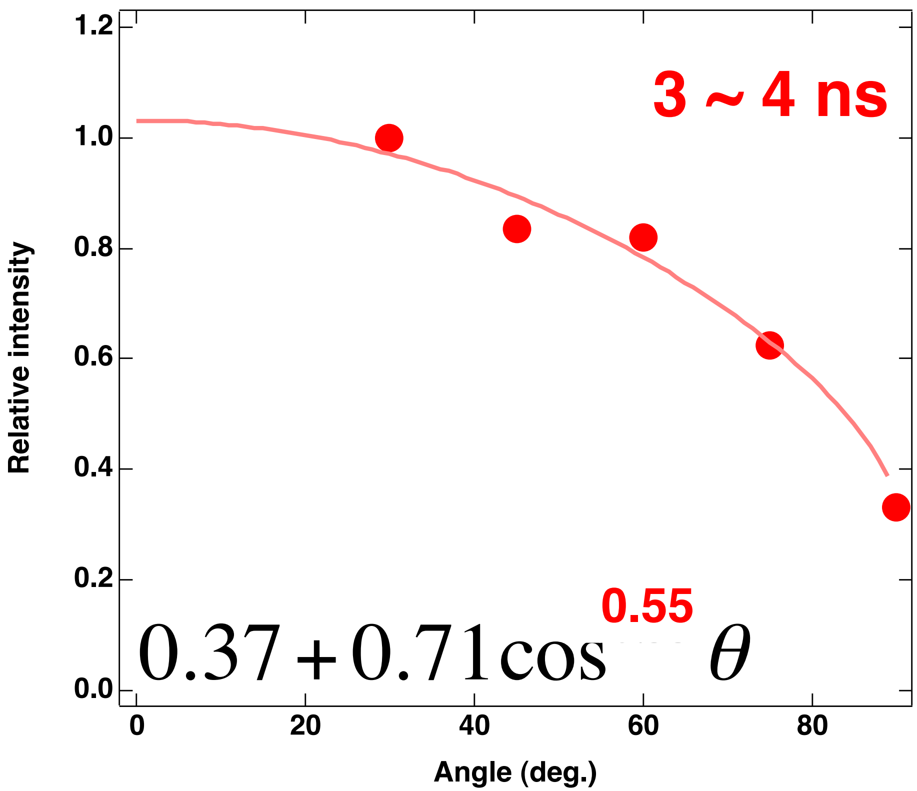
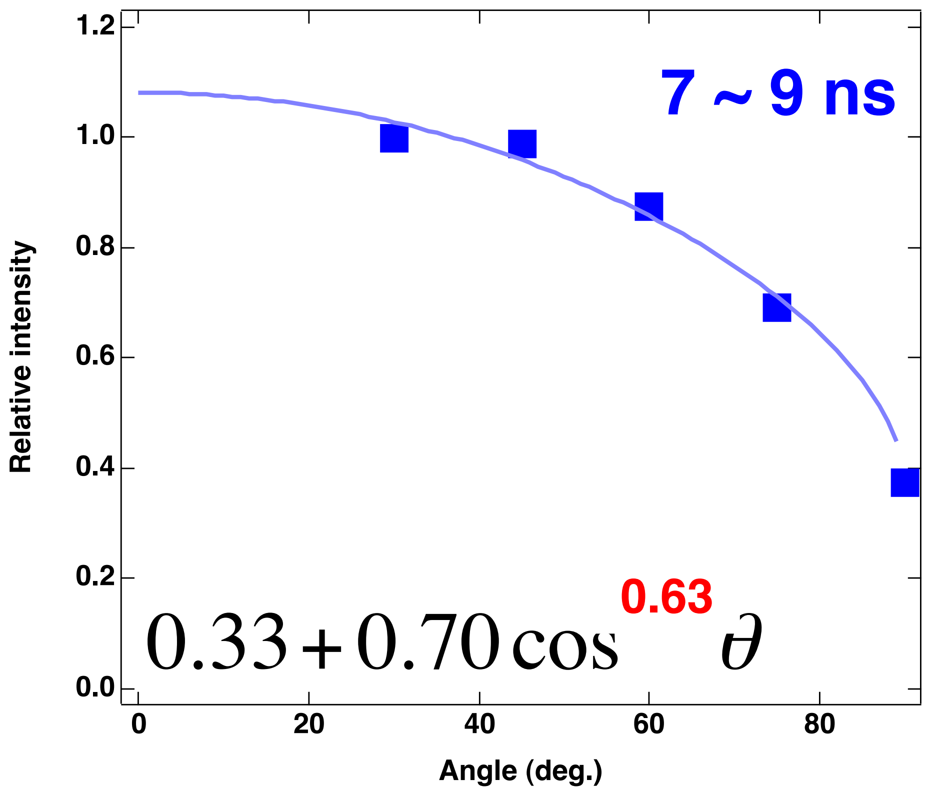
Angular distribution of 6.7 nm light emission





This is consistent with the in-band images.

6.X nm CEs depend weakly on the pulse duration.
1.5 – 1.7% of CEs are attained with Nd:YAG laser.

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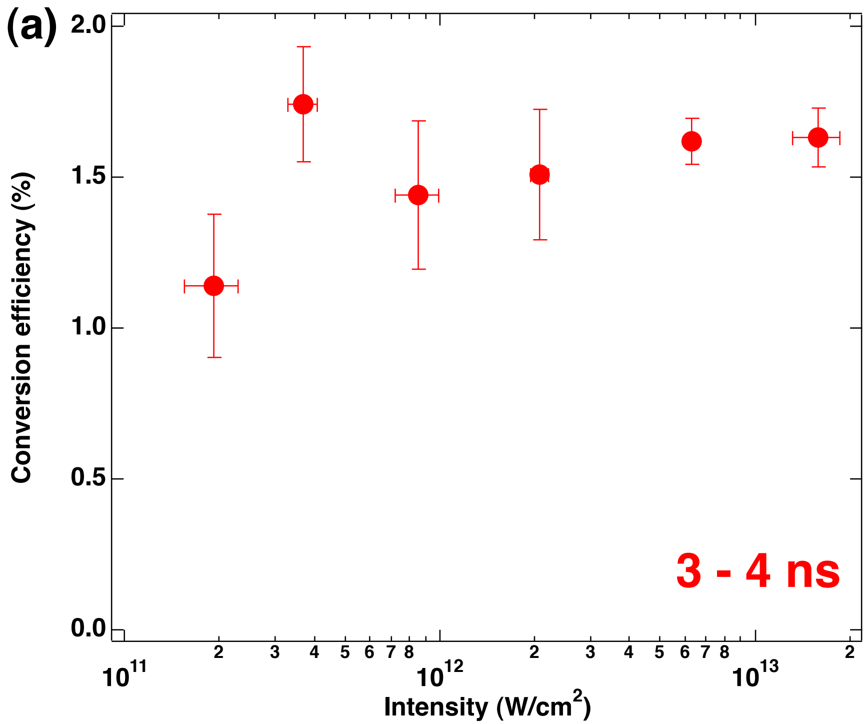
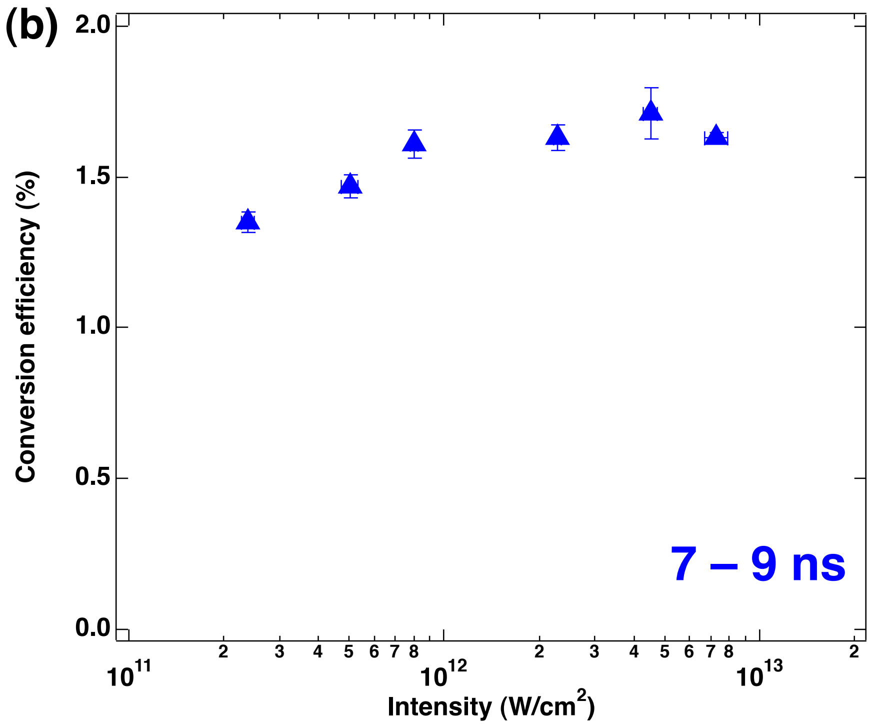
Energy conversion efficiency from laser to 6.7 nm within 2%BW





Dependence of EUV-CEs on pulse duration is small compared to that on a Sn-based 13.5 nm source.

Spectrum and CE have been measured to identify thickness required for sufficient in-band emission.

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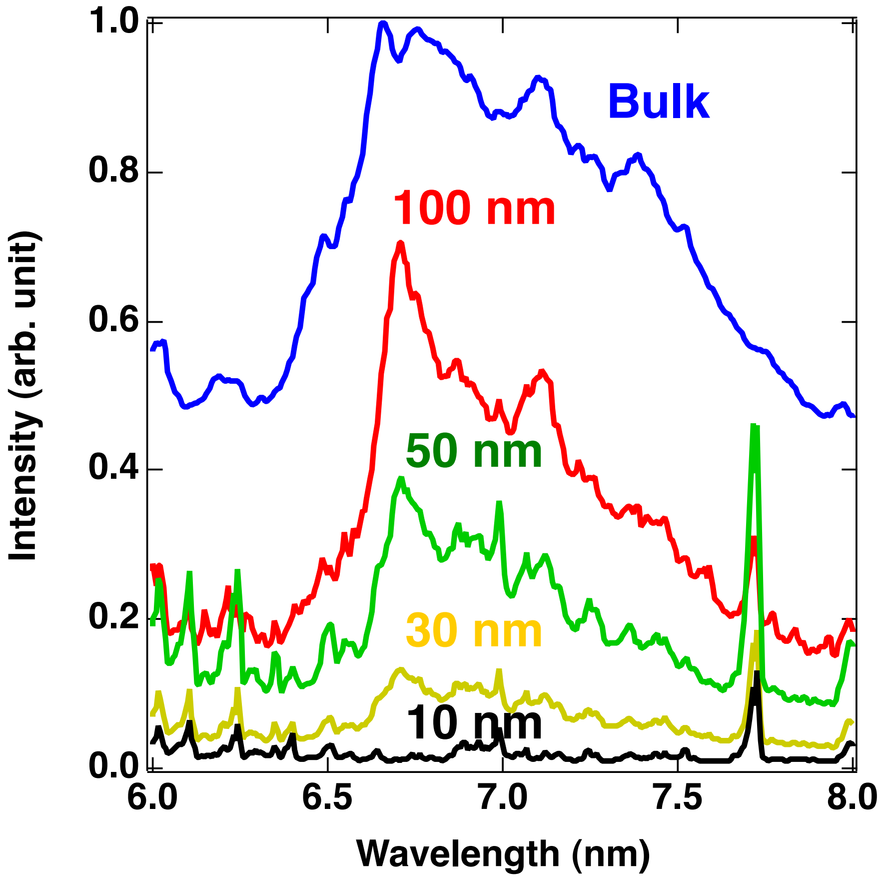
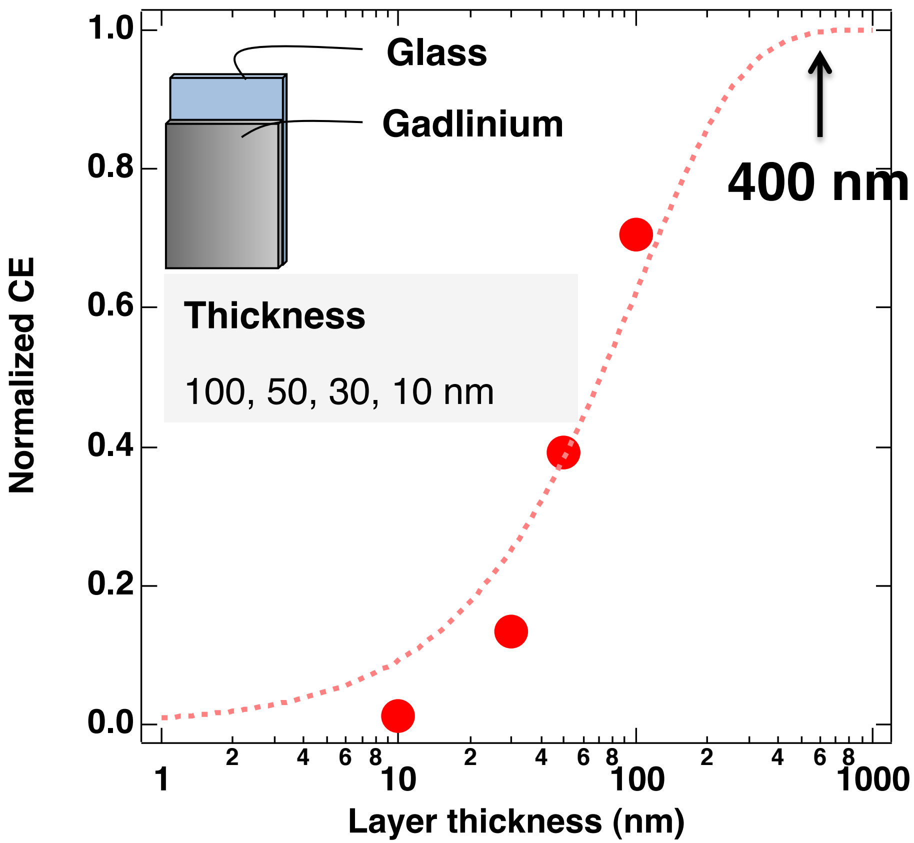
Spectrum vs. Thickness



CE vs. Thickness



400 nm thickness is required for sufficient in-band emission.

Punch-out scheme will be studied to supply minimum mass Gd targets for a clean and powerful source.

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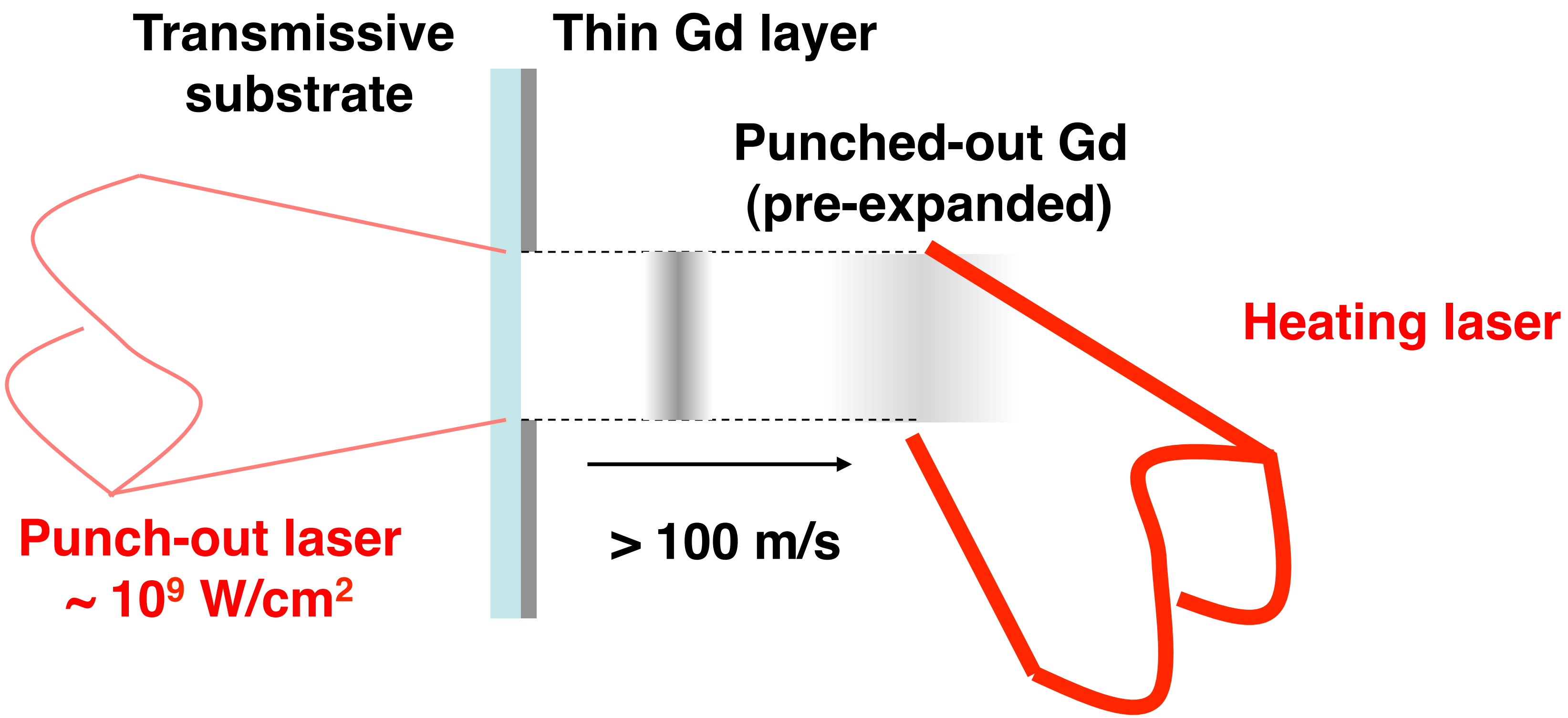
Schematic of the punch-out scheme



- Minimization of ionic- and neutral debris generation.
- High-speed and -repetition supply of Gd target.
- Easy to synchronize with the heating laser.

High melting temperature (1600 K) of Gadolinium may be preferable for the punch-out scheme.

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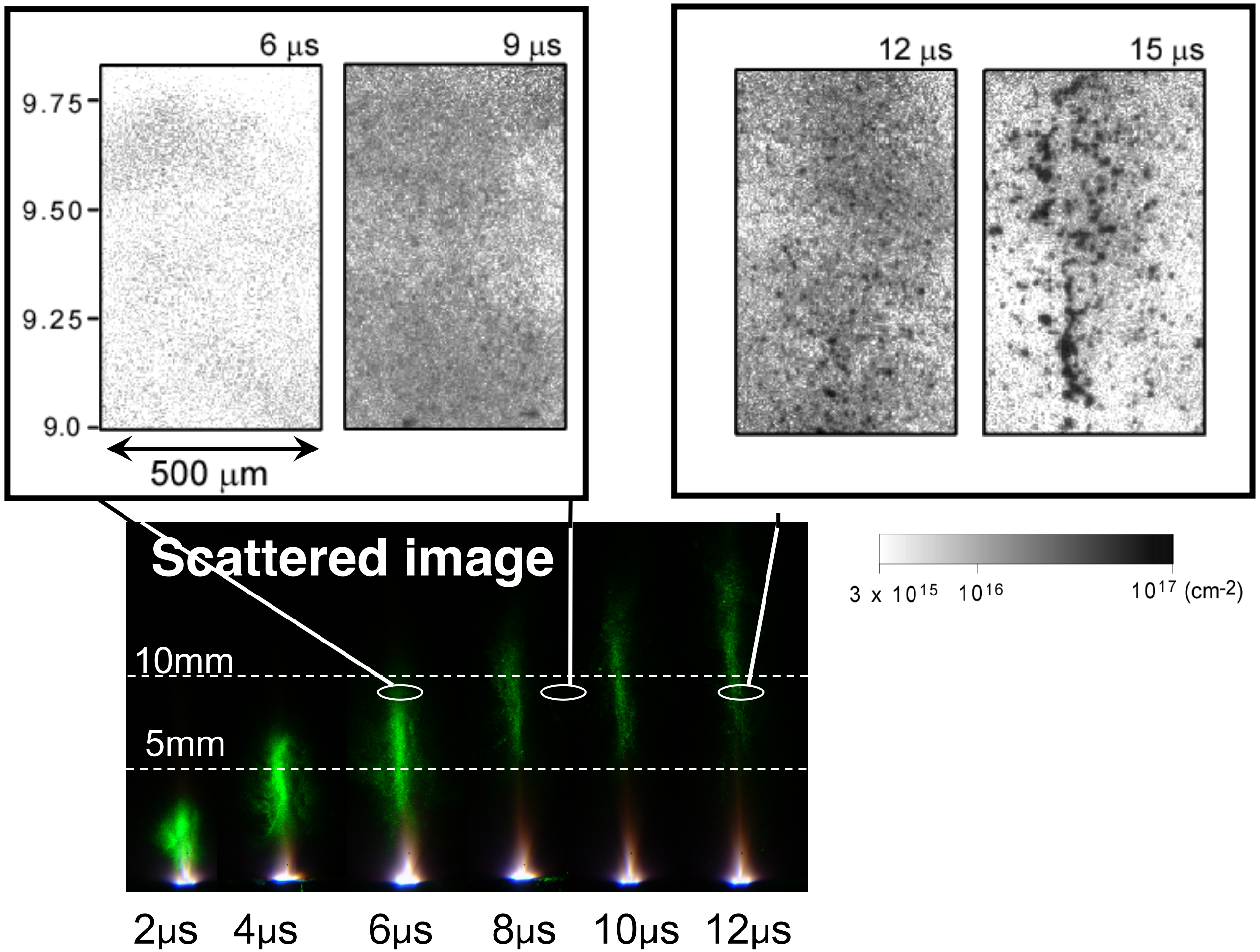
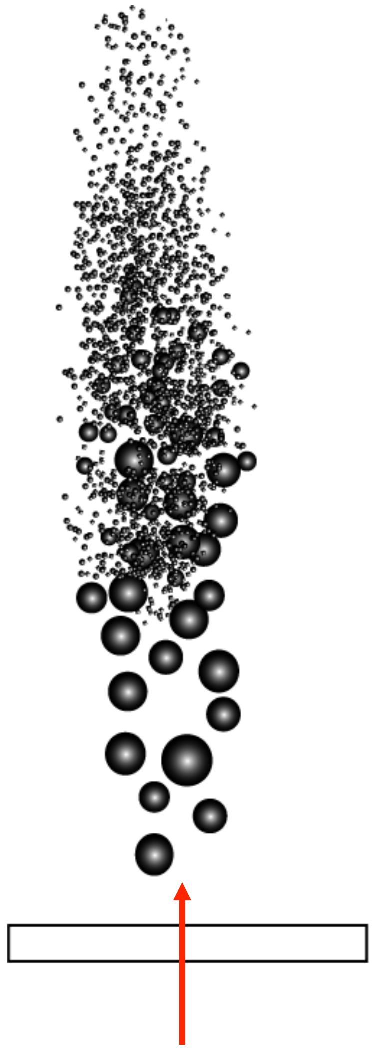
Shadow images of punched-out Sn target@9 mm





Melted tin layer is broken into particles and droplets.

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